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Prevalence of obstructive lung disease in a general population: relation to occupational title and exposure to some airborne agents

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Abstract

Background **The importance of occupational exposure to airborne agents in the development of obstructive disease is uncertain. Studying the relation in a community population has the benefit of reducing the healthy worker effect seen in studies of working populations.**

Methods **The prevalence of obstructive lung disease was examined in a Norwegian general population aged 18–73 in a two phased cross sectional survey. In the second phase a stratified sample (n = 1512) of those responding in the first phase was invited for clinical and spirometric examination (attendance rate 84%). Attenders were asked to state all jobs lasting >6 months since leaving school and to say whether they had been exposed to any of seven specific agents and work processes potentially harmful to the lungs.**

Results **The prevalence of asthma and chronic obstructive lung disease was 2·4% and 5·4%, respectively; spirometric airflow limitation (FEV_1/FVC < 0·7 and FEV_1 <80% of predicted values) was observed in 4·5% of the population. All jobs were categorised into three groups according to the degree of potential airborne exposure. Having a job with a high degree of airborne exposure increased the sex, age, and smoking adjusted odds ratio for obstructive lung disease (asthma and chronic obstructive lung disease) by 3·6 (95% confidence interval 1·3 to 9·9) compared with having a job without airborne exposure; the association with spirometric airflow limitation was 1·4 (0·3 to 5·2). Occupational exposures to quartz, metal gases, aluminium production and processing, and welding were significantly associated with obstructive lung disease after adjusting for sex, age, and smoking habit, the adjusted odds ratios varying between 2·3 and 2·7. Occupational exposure to quartz and asbestos was significantly related to spirometric airflow limitation in people older than 50.**

Conclusion **Occupational title and exposure to specific agents and work processes may be independent markers of obstructive lung disease in the general population.**

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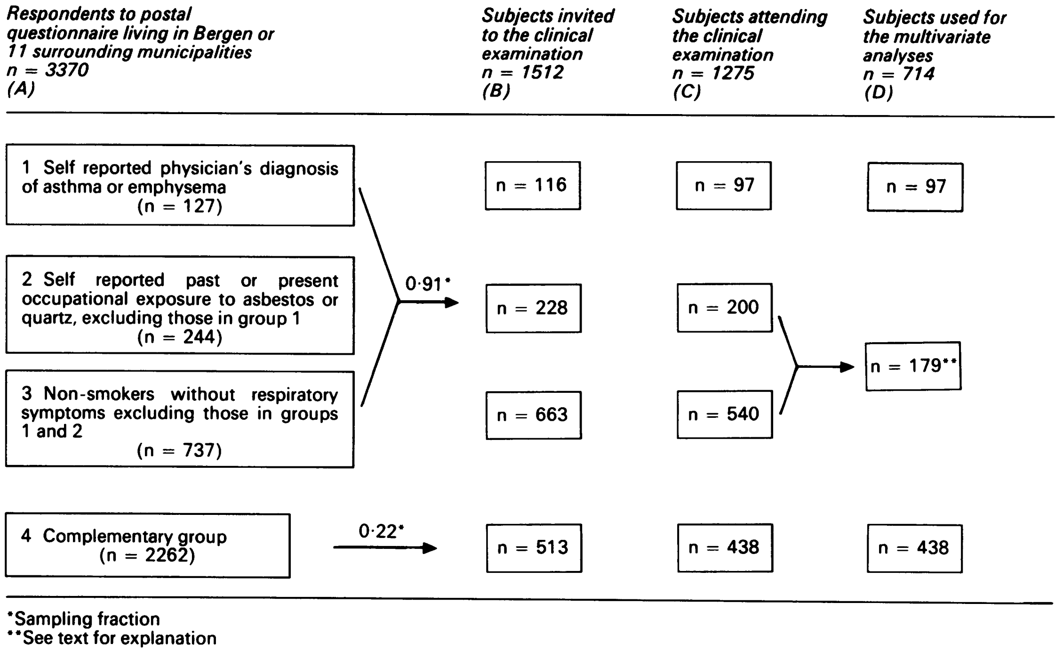
Mortality and morbidity from obstructive lung disease has increased.[1-3] The role of occupational exposure to airborne agents in the development of the disease has been examined in various community studies.[4-7] Examining the relation between occupational exposure and obstructive lung disease in community samples rather than working populations has the advantage of reducing the effect of healthy workers as subjects are studied regardless of their present occupational state. However, the characterisation of occupational exposure in population surveys is imprecise, having been based on self reported answers to non-specific questions on exposure to dust, gas, or fumes.[5 7] Few studies have examined the relation of specific agents to respiratory disorders in a general population. In a report including 1195 men from the Tucson study subjects reporting exposure to silica and fibreglass had higher age and smoking adjusted rates of airways obstruction than did those who were unexposed.[4] A recent Dutch study of 939 men (mean age 72) found an association between chronic non-specific lung disease and occupational exposures to organic dust, paint, heat, and working outdoors, as assessed by a job exposure matrix.[8] Whether previous or current occupational title is a marker for obstructive lung disease is not known.

The objectives of this survey of a Norwegian general population were (*a*) to examine the prevalence of obstructive lung disease by sex, age, smoking habit, and area of residence and (*b*) to assess the relation of obstructive lung disease to airborne occupational exposure as indicated by occupational title and self reported exposure to some specific agents and work processes.

Subjects and methods

STUDY POPULATION

The study was a two phased cross sectional community survey. In the first phase, conducted from September to December 1985, a questionnaire was posted to a random sample of 4992 people from the 267 304 inhabitants aged 15–70 years in the county of Hordaland, Norway. The county is mountainous, broken up by deep fjords. Most of the people live along the coast line. Bergen is the only city and is home to half the population of the county. In 1980 the working population of the county worked in industry (21%), construction (9%), agriculture and fishing (5%), and private and



Second phase of general population survey of Bergen and 11 surrounding municipalities. Numbers of people in each stratum, of invited people, of attenders of clinical examination, and of people used in multivariate analyses.

public services (64%).[9] The main industries are engineering, shipbuilding, food production, and graphics and publishing. Net income per head in 1987 was £6700.[10] The mean annual migration during 1986 to 1988 was 8453 subjects out of the county and 7421 into it.[11]

The questionnaire asked for information on smoking habits, occupational exposure to dust or gas, and respiratory disorders. The response rate was 90%.[12] The respondents living in Bergen and 11 surrounding municipalities (n = 3370) were divided into four strata based on the information obtained from the postal survey (figure). The aims of our survey were to obtain precise estimates of the prevalences of obstructive lung disease and occupational exposure to asbestos or quartz in the general population. Furthermore, a large subsample of non-smokers without symptoms was necessary to show the dispersion of lung function variables in a reference population with high precision. Thus a 0·91 random sampling fraction of the subjects in strata 1–3 and a 0·22 random sampling fraction of the subjects in stratum 4 were invited from April 1987 to August 1988 to the Outpatient Chest Clinic, Department of Thoracic Medicine, University of Bergen. The examination included respiratory physiological and clinical examination as well as characterisation of occupational exposure. The overall attendance rate was 84% (1275/1512).

Prevalence estimates and bivariate analyses are based on the 1275 attendants (figure, column C), taking into account the sampling fractions of the strata.[13] Multivariate analyses of exposure-disease associations were not performed on all the attenders because the sample was drawn with higher fractions of both exposed and diseased subjects. Valid estimates of exposure-disease association through multivariate analysis were obtained from a sample stratified by disease alone. Such a sample was obtained by drawing a sample fraction of 0·22 from strata 2 and 3 as originally done for stratum 4. When the observed attendance rate of 83% for people in strata 2 and 3 is taken into account, a total of 179 subjects should be included in the analysis. These 179 subjects (column D) were drawn at random from the 740 people available in the two strata. All multivariate analyses presented in tables 4–6 were performed on this sample of 714 subjects.

RESPIRATORY PHYSIOLOGICAL TESTS AND CLINICAL EXAMINATION

The forced vital capacity (FVC) and the forced expiratory volume in one second (FEV_1) were measured with a Gould 2100 pulmonary function spirometer (Gould Electronics BV Medical Products, Bilthoven, the Netherlands). The spirometer was calibrated daily with a 3·00 l syringe. The ventilatory tests were performed while the subject was seated and wearing a nose clip. The subject was carefully instructed in the procedure with standardised instructions. At least three spirometric measurements, in which the two largest FVC were reproducible to within 300 ml, were obtained from each subject. If eight trials were performed without an acceptable measurement the test was terminated. The largest FVC and the largest FEV_1 were used for analysis even if they did not come from the same forced expirations. The results are given as BTPS.

Subjects with spirometric airflow limitation were defined as those with a ratio of FEV_1 to FVC of less than 0·7 and an FEV_1 less than 80% of predicted values. Identical criteria were recently used in a population survey in Copenhagen.[14] The applied regression coefficients for FEV_1 from a Norwegian reference population[15] were in men: FEV_1 (l) $= -4{\cdot}540 + 5{\cdot}742 \times$ height (m) $- 0{\cdot}032 \times$ age (years), and in women: FEV_1 (l) $= -1{\cdot}220 + 3{\cdot}278 \times$ height (m) $- 0{\cdot}027 \times$ age (years). The mean FEV_1 in non-smokers without symptoms in this study was 102% (SD 12%) in women and

99% (10%) in men. The applied reference values should thus be relevant for the present population. In sixteen subjects (1·3%) spirometric results did not meet the criteria of an acceptable measurement.[16] For the sample on which the multivariate analyses were performed, eight subjects did not have acceptable spirometric measurements and were excluded from the analyses on spirometric airflow limitation.

The clinical examination aimed at determining whether the subjects had obstructive lung disease—that is, asthma or chronic obstructive lung disease by diagnostic criteria applied in a previous Norweigian survey.[15] Asthma was diagnosed in those with a history of attacks of shortness of breath at rest, with wheezing in the chest changing in severity over short periods of time, either spontaneously or after treatment. At least one typical attack had to have occurred within the previous six months. Chronic obstructive lung disease was diagnosed in those with a history of chronic cough; phlegm when coughing; breathlessness or wheezing, or both; and a ratio of FEV_1 to FVC of less than 0·7.

The occupational exposure of the subjects was not known to the physician making the diagnostic decision or to the laboratory technician performing the spirometric tests.

CHARACTERISATION OF EXPOSURE

The examination included completion of a questionnaire on smoking habits and all jobs held lasting more than six months since leaving school. Furthermore, the questionnaire asked for past or present occupational exposure to any of the following agents and work processes: asbestos, quartz, wood dust, metal gases (chromium, nickel, platinum), aluminium production and processing, welding, and soldering. The alternatives for answering were "yes" and "no." The questionnaire was checked for completeness by two members of the survey team. For each job the occupational title was obtained. The occupational titles were coded according to the three digit numbers of the Nordic Classification of Occupations, which follows the recommendations of the International Standard Classification of Occupations.[17] The occupations were allocated to three exposure categories (AE−, no airborne exposure; AE+, moderate degreee of airborne exposure, and AE++, high degree of airborne exposure) according to anticipated airborne exposure in that particular occupation. The term airborne exposure included dusts, fumes, mists, and gases.[18] This allocation was performed by three experts in occupational medicine and hygiene who did not otherwise participate in the field work. Each subject was categorised according to his or her present job and the longest job held. The complete list of occupations allocated to the three exposure groups may be obtained from the principal author (PB). Examples of AE++ occupations were foundry workers, painters, and insulation workers; of AE+ occupations farmers, greasers, weavers, and typographers; and of AE− occupations teachers, fishermen, clerks, and taxi drivers.

Non-smokers were defined as subjects who had never smoked daily. Ex-smokers were subjects who had smoked and had given it up. Subjects were classified as smokers if they were smoking daily at the time of the study.[19]

Table 1 Characteristics of attenders and non-attenders in second phase of general population survey of Bergen and 11 surrounding municipalities

Variable	*Attenders (n = 1275)*	*Non-attenders (n = 237)*
Sex:		
Women (%)	49	47
Mean age (SD) (years)*	42 (16·1)	37 (16·9)
Smoking habit:†		
Smokers (%)	29	27
Cigarettes/day (mean (SD)	15 (5·5)	14 (6·8)
Ex-smokers (%)	14	15
Non-smokers (%)	57	59
Area of residence:		
Urban (%)‡	68	68
Past or present occupational exposure to dust or gas (%)†	32	30
Self reported physician's diagnosis of asthma (%)†	7	7

*Age on 31 December 1987.
†Information from postal questionnaire.
‡Living in the municipality of Bergen.

ANALYSIS

Unpaired *t* tests were used to compare attenders and non-attenders by sex, age, smoking habit, occupational exposure state and self reported physician's diagnosis of asthma. The prevalence estimates presented in tables 2 and 3 and in the text are representative of the community because they are corrected for the stratification as in a two phased sampling procedure.[13] Frequencies were compared by the exact test for fourfold tables. The multivariate relation of asthma, chronic obstructive lung disease, and spirometric airflow limitation with respect to sex, age, smoking habit, and area of residence were examined by logistic regression analysis. When the association between disease and occupational exposure was examined by logistic regression analysis, asthma and chronic obstructive lung disease were analysed as one group. Separate analyses of those with asthma led to unstable regression coefficients owing to the few asthmatic subjects with exposure. The logistic regression analysis went backwards, stepwise. For all analyses a significance level of $p = 0.05$ was used. All analyses were performed with the BMDP package.[20]

Results

REPRESENTATIVENESS OF ATTENDERS IN RELATION TO THOSE INVITED

The attenders and non-attenders in the second phase of the study were comparable in sex distribution but attenders were significantly older (table 1). No significant difference was found for smoking habit, prevalence of self reported physician's diagnosis of asthma, or self reported past or present occupational exposure to dust or gas (table 1).

Table 2 Estimated prevalences (percentages (SE)) of asthma, chronic obstructive lung disease (COLD), and spirometric airflow limitation by sex, age, smoking habit, and area of residence in general population of Bergen and 11 surrounding municipalities, 1987–8

Variable	n*	Asthma	COLD	Spirometric airflow limitation†
Sex:				
Men	653	1·5 (0·4)	5·6 (1·1)	4·8 (1·0)
Women	622	3·0 (0·8)	5·2 (1·1)	4·2 (1·0)
Age (years):				
18–34	479	3·5 (1·0)	0·9 (0·6)	0·9 (0·8)
35–54	445	2·4 (0·8)	3·4 (1·1)	1·8 (0·7)
55–73	351	0·6 (0·3)	13·5 (2·2)	11·2 (2·0)
Smoking habit:				
Non-smoker	697	1·9 (0·6)	2·0 (0·7)	2·6 (0·9)
Ex-smoker	225	1·4 (0·8)	5·8 (1·7)	4·3 (1·7)
Smoker	353	3·0 (1·0)	8·2 (1·6)	5·6 (1·3)
Area of residence:				
Urban	861	1·7 (0·4)	6·4 (1·0)	5·4 (1·0)
Rural	414	3·7 (0·1)	3·3 (1·0)	2·7 (0·9)
Total	1275	2·4 (0·5)	5·4 (0·8)	4·5 (0·7)

*Sixteen subjects were excluded from analyses on spirometric airflow limitation because criteria for an acceptable spirometric test were not met.
†$FEV_1/FVC < 0·70$ and $FEV_1 < 80\%$ of predicted values.[15]

DESCRIPTION OF SUBJECTS

Of the 1275 attenders, 38 had asthma, 65 chronic obstructive lung disease, and 52 spirometric airflow limitation. The mean age of those with asthma was 40 and the mean FEV_1 90% (SD 13%) of predicted values. The corresponding figures in those with chronic obstructive lung disease was 56 and 63% (16%) and in those with spirometric airflow limitation 58 and 60% (15%). In those with chronic obstructive lung disease and spirometric airflow limitation FEV_1% predicted fell with increasing age, being 10–15% lower in those aged 54–73 than in those aged 18–34 years. This trend was not evident among those with asthma.

ESTIMATED PREVALENCES OF AIRWAY DISEASE

The estimated prevalence of obstructive lung disease (asthma or chronic obstructive lung disease) was 7·7% (95% confidence interval 5·9% to 9·5%) (table 2). The estimated prevalence of spirometric airflow limitation was 4·5% (3·1% to 5·9%). There was no crossover between asthma and chronic obstructive lung disease. Spirometric airflow limitation was observed in three subjects with asthma and 45 subjects with chronic obstructive lung disease. Asthma was present in a third of those with obstructive lung disease. The prevalence of obstructive lung disease did not differ significantly between the sexes (table 2). The prevalence of asthma tended to decrease with age, while those of chronic obstructive lung disease and spirometric airflow limitation increased heavily with age. The prevalence of asthma did not vary significantly with smoking habits, but chronic obstructive lung disease and spirometric airflow limitation were two to four times more common among smokers than non-smokers. Both chronic obstructive lung disease and spirometric airflow limitation were more prevalent in urban than rural areas, but this difference disappeared after adjusting for age. The estimated prevalence of subjects with a ratio of FEV_1 to FVC of $<0·50$, 0·50–0·59, and 0·60–0·69 was 0·8%, 1·0%, and 4·1% respectively in this general population aged 18–73. Overall, 12% had an FEV_1 less than 80% of predicted values (table 3). In those with an FEV_1 to FVC ratio of $<0·70$ and an FEV_1 below 80% predicted there was no significant sex difference in estimated prevalences at any degree of airflow obstruction (table 3). The prevalence of all degrees of airflow obstruction was higher in the oldest age group than in the youngest (table 3). Overall, 9·0% of the men and 6·9% of the women had a restrictive spirometric pattern ($FEV_1/FVC \geq 0·70$ and $FEV_1 < 80\%$).

MULTIVARIATE RELATION OF AIRWAY DISEASE TO SEX, AGE, AND SMOKING HABIT

The sex and smoking adjusted odds ratio for

*Table 3 Estimated prevalences (percentages (SE)) of various indices of spirometric airflow limitation by sex and age in general population aged 18–73 years of Bergen and 11 surrounding municipalities, 1987–8 (n = 1259)**

FEV_1 (% of predicted values)†	$FEV_1/FVC < 0·70$		$FEV_1FVC \geq 0·70$		Total	
	Men	Women	Men	Women	Men	Women
			Aged 18–44			
<40	—	0·1 (0·1)	—	—	—	—
40–59	0·4 (0·2)	0·1 (0·1)	—	—	0·4 (0·2)	0·1 (0·1)
60–79	1·9 (0·9)	0·6 (0·6)	5·4 (1·4)	5·8 (1·6)	7·3 (1·6)	6·4 (1·7)
≥80	1·3 (0·6)	1·2 (0·6)	91·0 (1·7)	92·1 (1·8)	92·4 (1·6)	93·4 (1·7)
Total	3·6 (0·9)	2·0 (0·7)	96·4 (1·5)	97·9 (1·5)	100·0	99·9
			Aged 45–73			
<40	0·6 (0·4)	0·2 (0·2)	—	—	0·6 (0·2)	0·2 (0·2)
40–59	4·8 (1·6)	2·3 (1·1)	1·0 (0·8)	0·9 (0·7)	5·8 (1·8)	3·2 (1·3)
60–79	3·8 (1·5)	5·8 (1·8)	13·1 (2·8)	7·5 (2·0)	16·9 (3·0)	13·3 (2·6)
≥80	2·4 (1·2)	0·9 (0·4)	74·2 (3·4)	82·4 (2·8)	76·6 (3·3)	83·3 (2·8)
Total	11·6 (1·8)	9·2 (1·7)	88·3 (2·1)	90·8 (2·2)	99·9	100·0
			Aged 18–73			
<40	0·2 (0·1)	0·2 (0·2)	—	—	0·2 (0·1)	0·2 (0·2)
40–59	2·1 (0·7)	1·1 (0·5)	0·5 (0·3)	0·4 (0·3)	2·6 (0·8)	1·5 (0·6)
60–79	2·5 (0·8)	2·9 (0·9)	8·5 (1·4)	6·5 (1·3)	11·0 (1·6)	9·4 (1·5)
≥80	1·9 (0·6)	1·1 (0·4)	84·2 (1·8)	87·9 (1·6)	86·1 (1·7)	89·0 (1·6)
Total	6·7 (1·2)	5·2 (1·0)	93·2 (1·7)	94·8 (1·7)	99·9	100·1

*Sixteen subjects were excluded from analyses on spirometric airflow limitation because criteria for an acceptable spirometric test were not met.
†Gulsvik.[15]

Table 4 Adjusted odds ratios with 95% confidence intervals for asthma, chronic obstructive lung disease (COLD), and spirometric airflow limitation by sex, age, smoking habit, and area of residence in general population aged 18–73 y of Bergen and 11 surrounding municipalities, 1987–8 (n = 714)

Variable	*Asthma (n = 33)*	*COLD (n = 52)*	*Neither asthma nor COLD (n = 629)*	*Odds ratio (95% confidence interval)*		*Spirometric airflow limitation*†		*Odds ratio (95% confidence interval)*
				Asthma	*COLD*	*Yes (n = 48)*	*No (n = 658)**	
Sex:								
Men	11	27	323	1	1	27	309	1
Women	22	25	306	1·9 (0·9 to 4·3)	0·9 (0·4 to 1·5)	21	349	0·7 (0·4 to 1·4)
Age (years):								
18–34	16	3	243	1	1	6	254	1
35–54	14	13	219	0·9 (0·4 to 1·9)	4·9 (1·4 to 17·6)	9	234	1·7 (0·6 to 4·8)
55–73	3	36	167	0·3 (0·1 to 0·9)	23·7 (6·9 to 81·3)	33	170	9·7 (3·8 to 24·5)
Smoking habit:								
Non-smoker	13	7	261	1	1	11	266	1
Ex-smoker	6	18	142	1·0 (0·4 to 2·7)	4·1 (1·6 to 10·8)	16	150	1·9 (0·8 to 4·4)
Smoker	14	27	226	1·1 (0·5 to 2·5)	8·0 (3·2 to 20·0)	21	242	2·9 (1·3 to 6·6)

*Eight subjects were excluded because criteria for acceptable spirometric test were not met.
†$FEV_1/FVC < 0{\cdot}7$, $FEV_1 < 80\%$ of predicted values.[15]

asthma in the oldest age group was a third of that in the youngest age group (table 4). Otherwise, none of the independent variables was significantly related to asthma in the logistic regression analysis. Age and smoking habits were independent predictors of chronic obstructive lung disease and spirometric airflow limitation after adjusting for sex by logistic regression analysis (table 4), although the adjusted odds ratios for spirometric airflow limitation tended to be lower than those for chronic obstructive lung disease.

OCCUPATIONAL AIRBORNE EXPOSURE AND AIRWAY DISEASE

Based on their present job, 3% of the population aged 18–73 years (men 5% and women 1%) had a job with an anticipated high degree of airborne exposure (AE++), while 26% (men 33%, women 20%) had a job with an anticipated moderate degree of airborne exposure (AE+). There was no difference in the mean age of the subjects in the three exposure groups. The prevalence of smokers was higher in those with AE+ and AE++ jobs than in those with AE− jobs when characterisation of exposure was based both on the present job and on the longest job held.

An AE++ job based on both present job and longest job held was significantly associated with obstructive lung disease (asthma or chronic obstructive lung disease) after adjusting for sex, age, and smoking habit by logistic regression analyses (table 5), but it did not predict spirometric airflow limitation significantly. An AE+ job based on either present job or longest job held did not significantly predict obstructive lung disease or spirometric airflow limitation. No interaction between occupational exposure and smoking habit was observed on a multiplicative scale.

Occupational exposure to one or more of the agents and work processes was reported by 57% of the men and 2% of the women and exposure to more than five agents and work processes by 4% of the men and none of the women. For all agents and work processes exposure was more often reported by men than women and by smokers than non-smokers. Only the lifetime prevalence of exposure to asbestos increased with increasing age.

When the relation between the airway diseases and occupational exposure to specific agents and work processes was considered, the adjusted odds ratios for obstructive lung disease or spirometric airflow limitation were greater than one in all analyses (table 6). Obstructive lung disease was significantly

Table 5 Adjusted odds ratios with 95% confidence intervals for obstructive lung disease and spirometric airflow limitation by occupational title of present job and job held longest in general population aged 18–73 of Bergen and 11 surrounding municipalities, 1987–8 (n = 714)

*Airborne exposure**	*Obstructive lung disease*† Yes (n = 85)	No (n = 629)	*Odds ratio (95% confidence interval)*‡	*Spirometric airflow limitation*§ Yes (n = 48)	No (n = 658)‖	*Odds ratio (95% confidence interval)*‡
Present job:						
AE−	52	446	1	30	467	1
AE+	25	166	1·4 (0·9 to 3·0)	15	169	1·2 (0·6 to 2·3)
AE++	8	17	3·6 (1·3 to 9·9)	3	22	1·4 (0·3 to 5·2)
Job held longest:						
AE−	43	387	1	27	404	1
AE+	35	226	1·2 (0·7 to 2·0)	18	236	1·1 (0·6 to 2·1)
AE++	7	16	2·5 (1·1 to 5·9)	3	18	1·5 (0·5 to 4·2)

*AE− no airborne exposure, AE+ moderate degree of airborne exposure, AE++ high degree of airborne exposure.
†Includes asthma and chronic obstructive lung disease (for definition, see text).
‡Adjusted for sex, age and smoking habit.
§$FEV_1/FVC < 0{\cdot}7$, $FEV_1 < 80\%$ of predicted values.[15]
‖Eight subjects were excluded because criteria for acceptable spirometric test were not met.

Table 6 Adjusted odds ratios with 95% confidence intervals for obstructive lung disease and spirometric airflow limitation by occupational exposure to specific agents and work processes in general population aged 18–73 of Bergen and 11 surrounding municipalities, 1987–8 (n = 714)

	*Obstructive lung disease**			*Spirometric airflow limitation‡*		
	Yes (n = 85)	*No (n = 629)*	*Odds ratio (95% confidence interval)†*	*Yes (n = 48)*	*No (n = 658)§*	*Odds ratio (95% confidence interval)†*
Asbestos	20	107	1·7 (0·7 to 3·9)	14	118	1·7 (0·7 to 3·9)
Quartz	12	50	2·3 (1·3 to 6·0)	7	53	1·8 (0·7 to 4·6)
Wood dust	9	38	1·8 (0·8 to 3·5)	5	34	1·5 (0·7 to 4·6)
Metal gases	17	69	2·3 (1·2 to 4·7)	9	69	1·3 (0·5 to 3·2)
Aluminium‖	9	31	2·7 (1·2 to 6·1)	4	35	1·5 (0·6 to 4·0)
Welding	16	68	2·2 (1·1 to 4·8)	8	74	1·2 (0·5 to 2·9)
Soldering	11	57	1·5 (0·7 to 3·3)	7	57	1·4 (0·5 to 3·7)

*Includes asthma and chronic obstructive lung disease (for definition, see text).
†Adjusted for sex, age and smoking habit.
‡$FEV_1/FVC < 0{\cdot}7$, $FEV_1 < 80\%$ of predicted.[15]
§Eight subjects were excluded because criteria for acceptable spirometric test were not met.
‖Aluminium production and processing.

associated with quartz dust, metal gases, and aluminium production and processing as well as welding.

None of the exposures was significantly related to spirometric airflow limitation after adjusting for sex, age, and smoking habit. As few young subjects had developed spirometric airflow limitation, the relation of the agents and work processes to spirometric airflow limitation was re-examined only in those older than 50. Asbestos and quartz exposure was significantly associated with spirometric airflow limitation after adjusting for sex, age (50–59, 60–73), and smoking habit by logistic regression, the adjusted odds ratio being 2·8 (1·1 to 7·3) in those exposed to asbestos compared with those who had not been exposed. The corresponding figure for quartz exposure was 3·7 (1·2 to 11·0).

Discussion

Although various definitions have been used for asthma and chronic obstructive lung disease, confusion persists about terminology and criteria.[21] In addition, the diagnoses are subject to considerable inter observer and intra observer bias.[15] As written criteria for asthma and chronic obstructive lung disease were applied and only one physician made the diagnosis, any variation within the present study should be small. Sampling bias could also affect the estimates of prevalence. However, surveys among the non-participants in the first[12] and second phases of the study showed no difference between participants and non-participants regarding sex distribution, smoking habit, respiratory symptoms, and self reported physician's diagnosis of asthma. The attenders in the second phase were, however, significantly older than the non-attenders (table 1). However, a response rate of 100% would only have changed the mean age of the attendants from 42 years to 41 years.

In previous surveys abnormal spirometric values have been characterised as $FEV_1 < 80\%$ of predicted values,[14,22] and other studies have used different cut off points.[23] This fixed value has no rational statistical basis in adults, although some studies have shown that for adults of average height and weight 80% of the predicted value is close to the fifth centile.[24] Use of a fixed value may result in shorter, older subjects being more readily classified as abnormal, while taller, younger subjects may erroneously be classified as normal.[22] Defining a fixed ratio of FEV_1 to FVC as the lower limit of normality also has disadvantages because the ratio is inversely related to age and is lower in men than in women.[15]

A community study in the county of Oslo, Norway, in 1974 of 19 998 subjects used the same diagnostic criteria for asthma and chronic obstructive lung disease as we did and found that 5·5% of the population aged 16–69 had obstructive lung disease.[15] This is significantly less than that observed in our study after adjusting for sex, age, and smoking habit. The mortality from obstructive lung disease (International Classification of Diseases 490–6) increased by about 30% and 60% from 1974 to 1988 in Hordaland and Oslo counties respectively, being 60% higher in Oslo than in Hordaland in 1988.[25,26] The ninth revision of the International Classification of Diseases in 1986 influenced mortality only slightly. Given that the relation between morbidity and mortality is the same in Oslo and Hordaland, this indicates that the prevalence of obstructive lung disease in Oslo would be 12·3% in 1988.

A population study in Copenhagen in 1981–3 of 4746 subjects aged 40–59 years found spirometric airflow limitation in 9·5% of the men and 8·6% of the women (spirometric airflow limitation being defined as $FEV_1/FVC < 0{\cdot}7$ and $FEV_1 < 80\%$ of predicted values). If we apply the Danish predictive values to our subjects aged 40–59, the prevalence of spirometric airflow limitation would be 4·5% in men and 4·8% in women. This finding is compatible with age adjusted mortality from obstructive lung disease (International Classification of Diseases (eighth revision) 490–3) since this was two to three times as common in Copenhagen as in Hordaland in both sexes in 1985.[27,28] The difference in prevalence of and mortality from obstructive lung disease may partly be because the prevalence of ever-smokers in Denmark is 80%[29] and in Norway 60%.[30]

Asthma tended to be more frequent in women than in men, and in younger than in older people. This is consistent with our observation that the prevalence of bronchial responsiveness to methacholine in this population is twice as high in women as in men.[31] The prevalence of FEV_1 adjusted bronchial responsiveness decreases with age.[31] This may be because changes in bronchomotor tone and bronchial smooth muscle with age reduce the capacity for bronchoconstriction in older compared with younger subjects, given an identical FEV_1. The prevalence of neither chronic obstructive lung disease nor spirometric airflow limitation differed significantly between men and women in our study. The absence of a sex relation was also observed in studies in Denmark[14] and Australia[23] but not in Finland,[32] the United States,[33] and France,[7] in which chronic obstructive lung disease was reported to be more common in men than women. This variation in disease prevalence by sex between studies may reflect dissimilarities in sex and age composition of the study populations. The studies in which no sex difference has been found are those that show the least difference in smoking habits between men and women, supporting the view that smoking is the main risk factor for obstructive lung disease.

This study showed that occupational title may be a risk factor for obstructive lung disease. Occupational title has previously been related to lung cancer in general population surveys in Norway.[34 35] A French community study of 16 464 subjects aged 25–59 years found that self reported exposure to dust, gases, or chemical fumes increased the odds for respiratory symptoms by about 1·5 ($p < 0{\cdot}01$).[7] A study of 8515 subjects aged 25–74 in six American cities found an increased risk of similar magnitude for the associations of dust, gases, and fumes with respiratory symptoms and chronic obstructive lung disease (defined as $FEV_1/FVC < 0{\cdot}6$).[6] An Italian community study of 3289 subjects aged $\geqslant 18$ found a relation between the single breath N_2 test, which is thought to reflect small airway state, and dust exposure in male smokers.[36] In a Norwegian population based case-control study of 108 men Kjuus *et al* found that workers in jobs where there was pollution had a three times higher risk of having emphysema than employees in clean jobs after age and smoking habit were adjusted for (polluting jobs were defined as those in which workers were regularly exposed to inhaled dust, vapours, or aerosols in their daily work).[37] On the basis of data from the questionnaire survey of this study we found that subjects reporting past or present occupational exposure to dust or gas had about a two times higher odds ratio for having respiratory symptoms than unexposed subjects after controlling for sex, age, smoking habits, and area of residence (urban or rural).[38] These associations, observed in different populations and by different study methods, support the hypothesis that there is a causal relation between occupational airborne exposure and obstructive lung disease. In this study there was a strong relation between AE+ + jobs and obstructive lung disease, the adjusted odds ratio being 3·6 (table 5). However, as only 3% of the population held an AE+ + job, the effect of eliminating airborne exposure in these jobs on disease prevalence in the community will be limited.

All the agents and work processes in our study have previously been associated with obstructive lung disease in occupational groups,[18 39–41] but only asbestos,[4] quartz[4] (S Humerfelt *et al*, 35th Nordic congress of pneumonology, Turku, 1990), and wood dust[4] have been associated in community surveys. Interpretation of our findings should be cautious because of the small number of subjects in each group, the high interdependence between several of the agents, and the unknown validity of the information on occupational exposure to the agents and work processes. The agents and work processes identified as risk factors for obstructive lung disease may be only crude estimates of an unhealthy work environment. For example, subjects exposed to aluminium dust may also be exposed to other agents used to produce and process aluminium[42]—for example, fluorides and sulphur dioxide—which have been shown to be related to obstructive lung disease.[18]

The relation of occupational exposures to the clinical diagnosis of obstructive lung disease was stronger than that to spirometric airflow limitation. The small number of subjects with spirometric airflow limitation suggests cautious interpretation of this finding. Subjects with obstructive lung disease included those with asthma so this finding may be because the level of occupational exposure in the general population is extensive enough to cause reversible airflow limitation and airway symptoms but not persistent airflow limitation. Theoretically, the finding could also be explained by selection by death from airflow obstruction in highly exposed subjects.

The validity of the observed exposure-disease associations may have been biased by several factors. Firstly, stratification by asthma and emphysema could bias the exposure-disease relation if exposed subjects report asthma or emphysema more readily than non-exposed subjects. However, this misclassification would be detected in the clinical examination. On the other hand, if truly diseased subjects tend to over report exposure compared with healthy subjects this would bias the results towards an association.

Secondly, occupational titles are only crude indicators of working conditions. Airborne exposures in the same occupation may vary considerably between individuals, over time, and between different workplaces. The consequent misclassification of exposure state would probably be non-differential with respect to disease state, and therefore tend to underestimate the true exposure-disease relation. Thirdly, the relation may be affected by recall bias. The accuracy of the data may decrease with the length of time since a job was held. However, a recent Swedish community study of 8870 subjects compared occupational history obtained from retrospective interview questionnaires with occupational information provided by censuses.[43] Although the quality of occupational information was best for recent jobs, it did not worsen significantly for jobs held up to 25 years back in time. Finally, socioeconomic state has been associated with both occupational exposure[6 7] and respiratory dis-

orders[7] and may therefore confound the exposure-disorder association. However, when socioeconomic state, based on formal education, was added to the logistic regression analysis in our study the exposure-disorder relationships were weakened only slightly without affecting significance.

This community study in northwestern Europe shows that obstructive lung disease is a common disorder affecting more than one in 15 adults. It indicates that occupational airborne exposure in addition to smoking is an environmental risk factor for the disease.

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